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Hybrid Surgical and Endovascular Approach via the Contralateral Superficial Middle Cerebral Vein to Occlude Cavernous Sinus Dural Arteriovenous Fistula in a Hybrid Operating Room: A Case Report

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Abstract

Most cases of cavernous sinus dural arteriovenous fistula (CS-dAVF) are treated via the inferior petrous sinus (IPS) through the transfemoral vein approach, but there are cases where treatment through the superficial middle cerebral vein (SMCV) is required. A hybrid operating room (OR) is useful because it allows for smooth direct surgery and endovascular treatment in a clean surgical field. We herein report a case of simultaneous treatment for CS-dAVF by coil embolization via a contralateral SMCV and middle cerebral artery (MCA) aneurysm by clipping in a hybrid OR. A 68-year-old woman had been suffering from left chemosis and ptosis for 2 months before visiting our hospital. Digital subtraction angiography (DSA) revealed Borden type II and Cognard type II a+b CS dAVF with parenchymal hemorrhaging and an unruptured left M1/M2 junction aneurysm. Since passing through the CS via the femoral vein was unsuccessful, we decided to access the right CS via the left CS through the intercavernous sinus (ICS) via the left SMCV by the pterional approach in a hybrid OR equipped with a multi-axis working system angiography machine. Endovascular treatment via direct cannulation into the contralateral SMCV following craniotomy in a hybrid OR is an optional strategy for treating complicated CS-dAVF.

Keywords: hybrid operating room, hybrid surgical and endovascular approach, cavernous sinus dural arteriovenous fistula, superficial middle cerebral vein, coil embolization

Introduction

A hybrid operating room (OR) enables the simultaneous performance of a hybrid surgical and endovascular approach for treating various brain disorders.[1,2] The access route for endovascular treatment, such as transvenous embolization (TVE) of cavernous sinus dural arteriovenous fistula (CS-dAVF), depends on the patency of accessible branches to the CS. We typically approach the CS through the inferior petrosal sinus (IPS) by a femoral venous approach.[3,4] Alternatively, we may approach through the superior orbital vein (SOV) via a facial vein. When neither the IPS nor orbital vein is accessible, we must consider other routes. Few reports have described the combined surgical and endovascular treatment of CS-dAVF via an ipsilateral superficial middle cerebral vein (SMCV).[3,4]

We herein report a case treated by a hybrid surgical and endovascular approach via a contralateral SMCV to occlude CS-dAVF with simultaneous clipping of

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unruptured aneurysm (uAN) of the left middle cerebral artery (MCA) in a hybrid OR.

Case Presentation

A 68-year-old woman had been suffering from left chemosis and ptosis for 2 months before visiting our hospital. Magnetic resonance imaging (MRI) revealed CS-dAVF accompanied by an expanded left SOV and left SMCV as well as uAN of the left MCA (Fig. 1A). At 1 week after admission, computed tomography (CT) showed a small parenchymal hematoma in the left temporal lobe (Fig. 1B). The left SOV was not depicted by MRI at that time (Fig. 1C).

Digital subtraction angiography (DSA) showed that the bilateral ascending pharyngeal arteries (APAs) were the main feeders (Fig. 1E–1H). There was a shunting point behind the right CS draining to the left CS through the intercavernous sinus (ICS) (Fig. 1E and 1G).

Left internal carotid angiography also showed a broad-neck aneurysm (7 mm) at the MCA of the M1/M2 junction (Fig. 1D). Although CVR to SMCV was already observed even though the left SOV was patent at admission, we considered that the occlusion of the left SOV induced the aggravation of CVR, which occurred intracerebral hemorrhage in the temporal lobe. We therefore decided to treat the CS-dAVF to prevent re-bleeding.

Although the bilateral IPSs were not depicted, we first tried to access the CS through the bilateral IPSs via the femoral vein. However, it was not possible to induce a microcatheter via the bilateral IPSs. The draining route was only the left SMCV. We ultimately decided to access the left CS via the left SMCV with the pterional approach in a hybrid OR equipped with a multi-axis working system angiography machine (Artis Zeego, Siemens, Germany) followed by the right CS through the ICS. We also planned the simultaneous clipping of the broad-neck uAN of the left MCA.

We performed left frontotemporal craniotomy and exposed the left SMCV (Fig. 2A) after opening the Sylvian fissure under general anesthesia. The SMCV was sufficiently isolated from the brain surface and secured with 6-0 silk thread. After clamping the proximal and distal SMCV with a temporary clip, the SMCV was punctured with a needle (Fig. 2B).

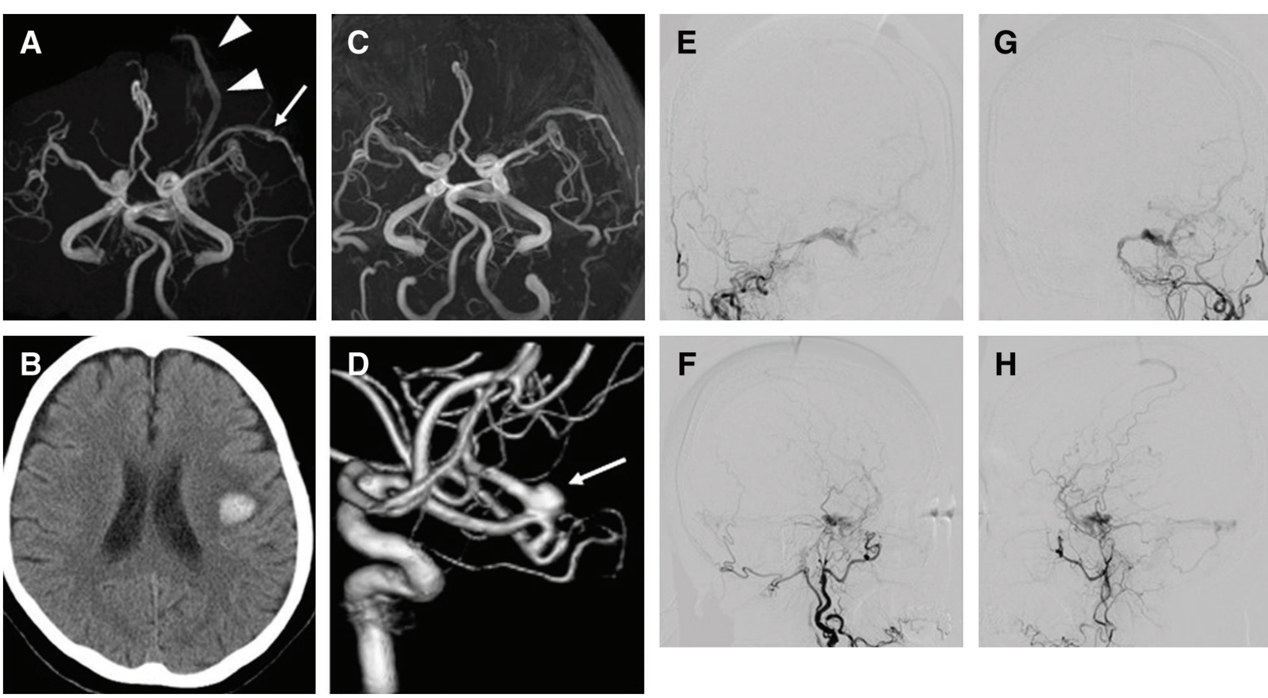

Fig. 1 Preoperative MR angiography, brain CT, DSA. MR angiography revealed CS-dAVF accompanied by an expanded left SOV (arrowheads) and left SMCV (arrow) (A). Brain CT showed a small parenchymal hematoma in the left temporal lobe (B). The left SOV was not depicted by MR angiography (C). Three-dimensional DSA of the left internal carotid artery showed a 7-mm broad-neck uAN at the left MCA M1M2 junction (arrow) (D). A right external carotid angiogram A-P view and lateral view (E, F). A left external carotid angiogram (G: A-P view, H: lateral view). A bilateral external carotid angiogram showed right CS-dAVF. CS-dAVF: cavernous sinus dural arteriovenous fistula, CT: computed tomography, DSA: digital subtraction angiography, MCA: middle cerebral artery, MR: magnetic resonance, SOV: superior orbital vein, uAN: unruptured aneurysm.

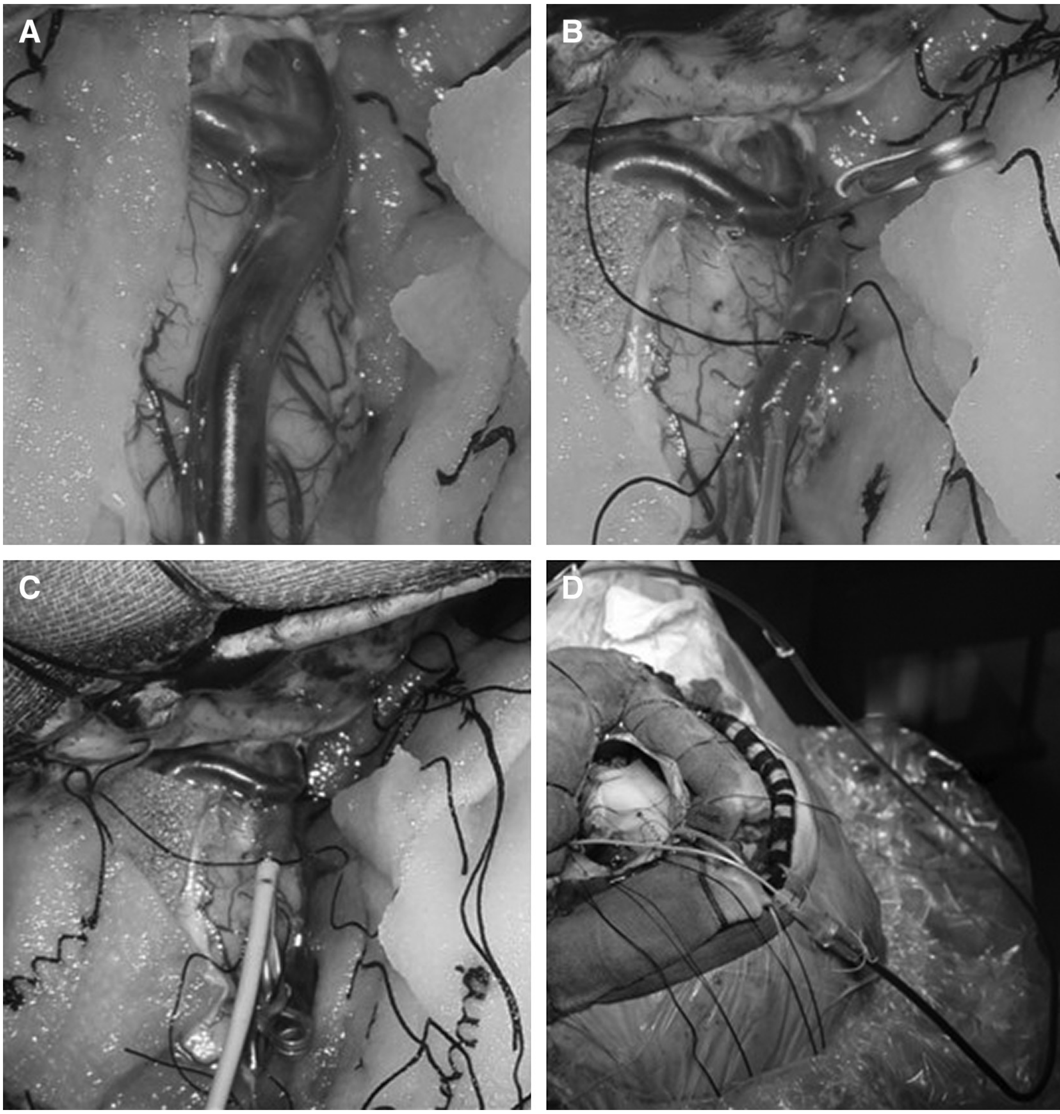

Fig. 2 Intraoperative photos (cannulation of the SMCV). We performed left frontotemporal craniotomy and exposed the SMCV (A). The SMCV was sufficiently peeled from the brain surface and secured with silk thread (B). After closing the proximal and distal part of the SMCV with a temporary clip, the SMCV was punctured with a needle. The sheath was inserted into the SMCV and fixed with silk thread under a microscope (C). A 50-cm extension tube was connected to the sheath to separate the portion receiving catheter surgery from the open surgery part (D). SMCV: superficial middle cerebral vein.

The sheath (4-Fr micropuncture introducer kit; Cook, Bloomington, IN, USA) was inserted into the SMCV and advanced into the sphenoparietal sinus before ultimately being fixed with silk thread (Fig. 2C). To reduce the radiation exposure to the surgeon, a 50-cm extension tube (Safido, 50 cm, 2.1 mm; TERUMO, Tokyo, Japan) was connected to Y connector (Gateway Plus Y Adapter; Boston Scientific, Marlborough, MA, USA) and perfuse heparinized saline to separate the catheter from the surgical field (Fig. 2D).

We then shifted to endovascular treatment (Fig. 3A). The microcatheter was barely able to be induced to the shunting point located behind the right CS through the ICS via the left CS (Fig. 3B) without heparinization. First, we placed the first coil in the right CS. After embolization of the right CS with five coils, the ICS was embolized with two coils. The left CS was then embolized with four coils (Fig. 3C). The microcatheter was also induced to the left superior petrosal sinus (SPS), which was embolized with four coils (Fig. 3D). After confirming the disappearance of the shunt, the endovascular treatment was finished (Fig. 3E and 3F). After the sheath placed in the SMCV was removed, the SMCV

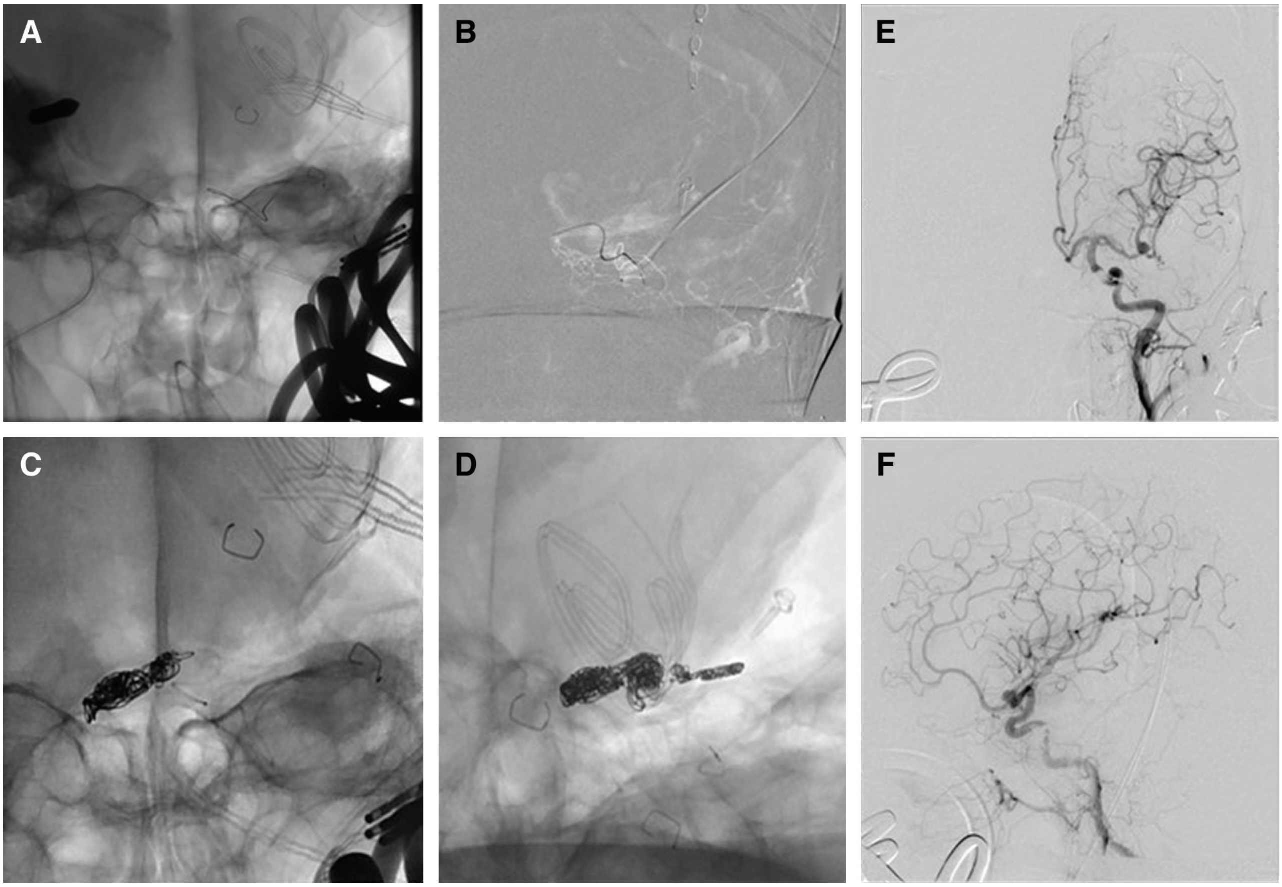

Fig. 3 Endovascular treatment. The microcatheter was induced to the shunting point behind the right CS through the left CS and ICS (A, B). After sinus packing by coil embolization from the right to left CS (C: A-P view, D: lateral view). Post-transcranial sinus packing left common carotid angiogram (E: A-P view, F: lateral view). CS: cavernous sinus, ICS: intercavernous sinus.

was ligated with silk thread because this SMCV is not related to normal venous drainage. Subsequently, the broad-neck MCA uAN was exposed, and three clips were applied. Finally, the CS-dAVF and left MCA uAN were no longer visible on intraoperative DSA (Fig. 4A–4D). Postoperative MRI revealed no procedural complications, such as distal embolism. MR angiography also showed that the abnormal venous expansion and left uAN in the left MCA had disappeared. Ten days after the operation, the patient was discharged without any neurological deficit.

Discussion

For the treatment of CS-dAVF, we commonly consider IPSs as the access route into the CS via the femoral venous approach and perform TVE.[3,4] IPSs are thrombosed occasionally, but we often can slip a catheter through the thrombosed IPSs. However, we occasionally must consider approaching the CS via an access route other than the IPS. The SPS, pterygoid venous plexus, and facial vein[5] are well-known alternate access routes that can be reached via the femoral venous approach. In the case that those access routes are not available, then opening a SOV by a direct puncture is a useful alternative.[4] If these access routes are not available, we must consider a transcranial route via a cortical vein or SMCV, which remains available as a drainage route.[5–7] In a previous case report, hematoma removal and transcranial embolization were performed in a single session to treat CS-dAVF.[8] Only four cases of treatment with transcranial catheter access into the CS via the SMCV have been reported.[7–10] This approach was chosen because of occlusion of other access routes in all four cases. One of the four cases had huge intracranial hemorrhaging. Two were treated with C-arm fluoroscopy in the OR,[7,8] while the device that was used to perform the angiographical evaluation was not mentioned in the other two cases. In our case, preoperative DSA demonstrated

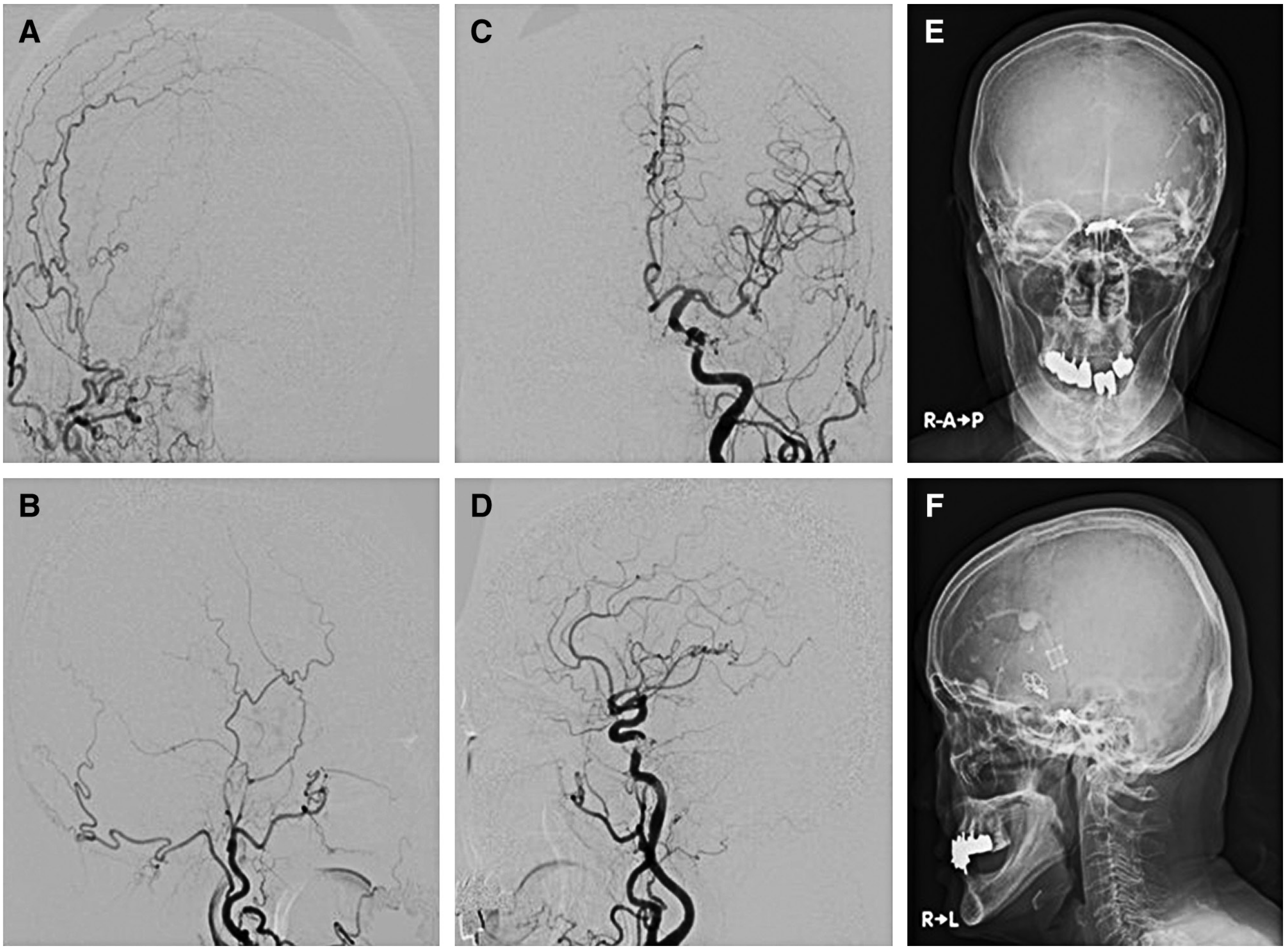

Fig. 4 A right external carotid angiogram (A: A-P view, B: lateral view). A left common carotid angiogram (C: A-P view, D: lateral view). A skull-XP after coil embolization and neck clipping (E: A-P view, F: lateral view).

that the drainage route was only left SMCV. Although we tried to access from bilateral IPS and SPS by transfemoral venous approach, we were not able to pass through them. Finally. We decided to select the left SMCV as the access route to CS. Furthermore, it was possible to safely advance the sheath to sphenopariteal sinus even without exposing CS directly, and then approached the contralateral CS using a microcatheter.

In our case, all procedures were performed in a hybrid OR. After endovascular treatment for CS-dAVF was completed, neck clipping of the MCA uAN was also performed. We ultimately confirmed the complete obliteration of the dAVF and aneurysm by intraoperative DSA. Since a hybrid OR enables the performance of direct surgery and endovascular surgery simultaneously, it is considered useful for stent-graft implantation for aortic aneurysm, trans-arterial aortic valve insertion (TAVI), and treatment of complicated cerebral aneurysm and cerebral arteriovenous malformation.[1,2] There are several advantages associated with a hybrid OR, such as secure transfer, higher-quality DSA, and cleanliness.[1] Furthermore, a hybrid OR makes us possible to smoothly transition to endovascular treatment from open surgery without any need for a transfer. The higher quality of angiography also allows us to perform complicated endovascular procedures, such as accessing the CS via the contralateral SMCV in our case. Angiography performed with a multi-axis working system is less restricted by the patient's posture during surgery. We can therefore use a hybrid OR for any brain surgery. However, one disadvantage of our hybrid OR is that since this angiography machine has only a single plane, we spend more time on endovascular procedures than with biplane equipment.

Conclusion

Although most cases of CS-dAVF are treated through the IPS via the transfemoral vein approach, there are cases where treatment via the SMCV is required.

The hybrid OR is useful because it allows us to perform direct surgery and endovascular treatment smoothly in a clean surgical field. Endovascular treatment via direct cannulation into the contralateral SMCV following craniotomy in a hybrid OR is an optional strategy for treating complicated CS-dAVF.

Conflicts of Interest Disclosure

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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